Many Ways to Write a Simple Function

In this lecture, we’ll look at many ways of writing a simple function called `is_not_decreasing`, which takes one argument, a vector, and returns TRUE if the elements in the vector are in non-decreasing order, and FALSE otherwise. We’ll see some new R features along the way.

Examples:

```r
> is_not_decreasing (c(4,8,8,9))
[1] TRUE
> is_not_decreasing (c(5,1,3))
[1] FALSE
> is_not_decreasing (7)
[1] TRUE
```

We’ll assume that the vector has no NA values. What would be a reasonable thing to do if it did?
Ending a Loop Using a Logical Flag Variable

Here’s one solution, that uses the setting of a logical variable as a way of terminating a while loop:

```r
is_not_decreasing <- function (v) {
  answer_is_known <- FALSE
  i <- 2
  while (!answer_is_known) {
    if (i > length(v)) {
      answer <- TRUE
      answer_is_known <- TRUE
    }
  } else if (v[i] < v[i-1]) {
    answer <- FALSE
    answer_is_known <- TRUE
  }
  i <- i + 1
}
answer
```
Using a `repeat` Loop and `break` Statement

This function used two logical variables — one to hold the answer returned, the other to indicate when the answer is now known, and hence the loop can end. We can instead use a loop written using `repeat`, which continues indefinitely, until a `break` statement is done:

```r
is_not_decreasing <- function (v) {
  i <- 2
  repeat {
    if (i > length(v)) {
      answer <- TRUE
      break
    }
    if (v[i] < v[i-1]) {
      answer <- FALSE
      break
    }
    i <- i + 1
  }
  answer
}
```
Using `break` Within a `for` Loop

We can use `break` to immediately exit any kind of loop. Here’s another way to write this function:

```r
is_not_decreasing <- function (v) {
    answer <- TRUE
    if (length(v) > 1) {
        for (i in 2:length(v)) {
            if (v[i] < v[i-1]) {
                answer <- FALSE
                break
            }
        }
    }
    answer
}
```

In this version, we initially set `answer` to `TRUE`, which will be the answer if we don’t find a place where the elements decrease. If we do find a decrease, we set `answer` to `FALSE`, and also immediately exit the `for` loop.

**Caution:** The `break` statement exits from the innermost loop that contains it. If you’re inside two loops, you can’t use `break` to exit both of them at once.
Returning a Value for a Function Immediately

Rather than exit a loop with `break` after setting `answer`, and then making `answer` the value of the function by putting it as the last thing, we can instead use `return` to exit the whole function, and specify the value it returns.

```r
is_not_decreasing <- function (v) {
  if (length(v) > 1) {
    for (i in 2:length(v)) {
      if (v[i] < v[i-1])
        return(FALSE)
    }
  }
  return(TRUE)
}
```

At the end, we could just have written `TRUE` instead of `return(TRUE) — they do the same thing at the end of a function.

Why is the check for `length(v) > 1` needed?
Avoiding Loops with a Vector Comparison

We can write `is_not_decreasing` without an R loop using a vector comparison and the `all` function:

```
is_not_decreasing <- function (v) all (v[-length(v)] <= v[-1])
```

In this version, `v[-length(v)]` will contain all of `v` except the last element, and `v[-1]` will contain all of `v` except the first element. So `v[-length(v)] <= v[-1]` compares each element except the last to the next element. The vector `v` is non-decreasing if all these comparisons are `TRUE`.

Here’s another way to do the same thing:

```
is_not_decreasing <- function (v) {
  if (length(v) < 2)
    TRUE
  else
    all (v[1:(length(v)-1)] <= v[2:length(v)])
}
```

Why is the check for `length(v) < 2` needed here, but not in the version above?
Recursion — When a Function Calls Itself

As you know, an R function can call another R function, which can call yet another R function, etc.

Indeed, an R function can even call itself. This is called “recursion”.

Of course, a function had better not always call itself, or it will just keep calling, and calling, and calling, without end.

But having a function sometimes call itself can be useful. Here’s a recursive function to compute factorials in R:

```r
fact <- function (n) if (n == 0) 1 else n * fact(n-1)
```

(Although R already has a pre-defined factorial function.)

In fact, anything computable can be computed using if and recursion, without any loops or assignment statements. That’s not a typical style of programming in R, but it is typical for some other programming languages.
Two Recursive Versions of `is_not_decreasing`  

We could write the `is_not_decreasing` function using recursion. Here’s one way:  

```r  
is_not_decreasing <- function (v) {  
  if (length(v) <= 1)  
    TRUE  
  else if (v[2] < v[1])  
    FALSE  
  else  
    is_not_decreasing(v[-1])  
}  
```

Here’s another way that doesn’t copy parts of `v`, and also extends the function’s meaning so it checks only from a certain point forward (default, from the start):  

```r  
is_not_decreasing <- function (v, from=1) {  
  if (length(v) <= from)  
    TRUE  
  else if (v[from+1] < v[from])  
    FALSE  
  else  
    is_not_decreasing(v,from+1)  
}  
```